Zoobenthos (II)

[Gili J.-P., Sardà R., Madurell T. et al., 2014. Zoobenthos. In: Goffredo S., Dubinsky Z. (eds) The Mediterranean Sea: Its history and present challeges. Springer, Dordrecht, p 213-236]

Ecological Strategies

Species fall into a bionomic or ecological continuum among the so-called *r* and *K* strategies (Pianka 1970; Margalef 1974).

R-strategist represents the opportunistic, fugitive, pioneer and generalist species. They exploit the lack of organization and environmental stability, with a high offspring production; the vast majority inevitably disappear. They are highly adaptable and frequent in unstable and stressed environments.

The *k*-strategist exemplifies the specialists or strategists. They can stabilize their populations in a given environment, and produce few very protected offspring that are well adapted to ecological stable environments.

Zoobenthos (II)

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Ecological Strategies

In the Mediterranean zoobenthos the ecological strategies can be summarized in the following trends:

<u>It the upper littoral levels</u>, the benthic strategies favoured are those that tend to counteract the <u>mechanical stress</u> associated with these shallow habitats. The balance between high illumination rates results in productive and dense algae communities that support a diverse and rich fauna. Because of the seasonal variations in algal cover, and the high environmental stress, <u>most species have high reproduction rates, production and fast turnover</u>.

<u>At intermediate levels such as the circalittoral</u>, the current stress is not mechanical but refers to <u>light availability</u>. Light decline reduces plant capacity to occupy the space, and therefore the competition with animals, especially sessile fauna, is maximal. Many species are builders, investing in three-dimensional structures. They have moderate to slow growth rates and a slow turnover.

<u>At deeper levels </u>(e.g. the deep circalittoral, dark caves or shelf-break communities) the stress is greater due to <u>high sedimentation</u> and the <u>scarce food supply</u>. In these environments <u>only animal </u>assemblages can survive, <u>mainly *k*-strategists</u>, and their adaptation is often determined by the acquisition of far-reaching specializations.

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Temporal Variability

Seasonal variations are common phenomena in all ecosystems.

Life cycles of marine organisms show marked seasonal patterns in growth, reproduction and abundance. In the water column, these seasonal cycles are directed by factors, such as photoperiod, food availability, oxygen, salinity and temperature.

Algae Dominated Communities

Temperate regions exhibit seasonal peaks in the standing stock of algae in late spring throughout summer and with minima in winter (Murray and Littler 1984).

There is also a shift in the time of production and biomass peaks, which take place in spring in shallow sublittoral algal communities, and in summer in the deeper assemblages.

The effects of fish and urchin grazing modify benthic communities and affect the composition, abundance and dynamics of shallow sublittoral algal communities. During the production phase of the algae, sea urchins display an overgrazing activity that reduce the algal biomass. In extreme cases, grazers reduce totally the erect stratum of fleshy algae, resulting in a monotonous assemblage of encrusting algae (Velarque 1987; Sala et al. 1998a, b; https://www.youtube.com/watch?v=PsUy7PdJyd8). In the Mediterranean fishes are not the dominant grazers and have less effect on algal abundance than sea urchins (Velarque 1990).

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Vagile Fauna

Much of the fauna that lives close to the bottom exhibits varying degrees of mobility, from crawling gastropod molluscs, starfishes and sea urchins to highly mobile mysidacea (opossum shrimps) and fish. These organisms perform seasonal migrations through a vertical gradient, avoiding high temperatures in summer and looking for food during winter in shallower habitats (San Vicente and Sorbe 2003; Bellan-Santini et al. 1994).

Crawling gastropod molluscs; Gastropoda, Prosobranchia

Starfishes; Echinodermata, Asteroidea

Sea urchins; Echinodermata, Echinoidea

Opossum shrimps; Crustacea, Malacostraca, Lophogastrida

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Vagile Fauna
Larval stages of many invertebrate and fish species use transitory habitats as an area for shelter and feeding.

Common types of transitory habitats are macroalgal beds (Bruno and Bertness 2001). During periods of high growth of the foliage and thalli, meadows of macro-algae provide shelter and protection to different stages of many marine species that are most vulnerable to predation.

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Animal-Dominated Communities

In deeper communities, dominated by animals, seasonal changes might be detected in the physiological parameters of animal populations such as reproduction periods or growth patterns (Turon and Becerro 1992; Garrabou et al. 2002; Blanquer and Agell 2008; De Caralt et al. 2008). Physiological parameters are closely related to food availability in the water column.

Food shortages in the water column are in summer and late autumn (Rossi et al. 2006a).

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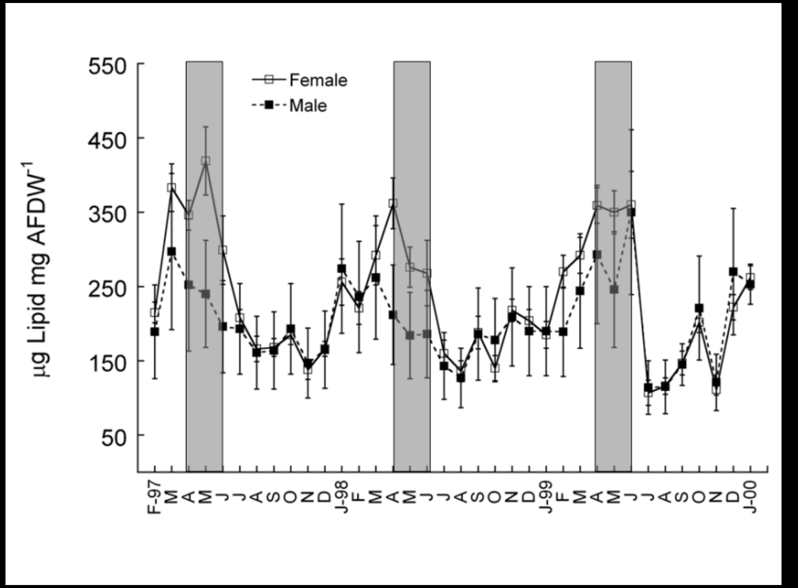
Animal-Dominated Communities

The seasonal variation of food availability can cause shifts in the resource allocation of benthic organisms (Caswell 1989).

The seasonal variation in the biochemical composition of the tissue of an organism may be interpreted as a record of the water column productivity fluctuations.

In general, the reproductive period occurs at the end of the most successful feeding period (feeding period in winter -> reproductive period in spring).



Three years cycle of the lipid contents in the gorgonian *Paramuricea clavata*. Shadow areas indicate reproduction period (Figure modified from Rossi et al. 2006a). The marked seasonality of food availability is reflected in the energy storage of mediterranean benthic suspension feeders. Food constraints are in summer (dormancy process), and in autumn (low quality seston). Reproduction success is tightly related with the energy storage capability

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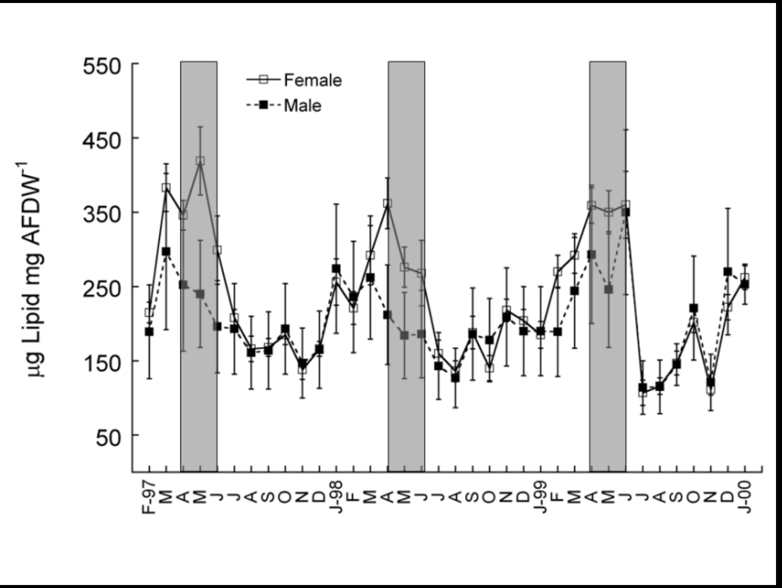
Animal-Dominated Communities

Another seasonal strategy related to the energetic constraints is a predictable pattern of temporal dormancy.

In the Mediterranean, summer dormancy predominates (Sardá et al. 1999; Garrabou 1999; Coma et al. 2000; Betti et al. 2012; Di Camillo et al. 2012).



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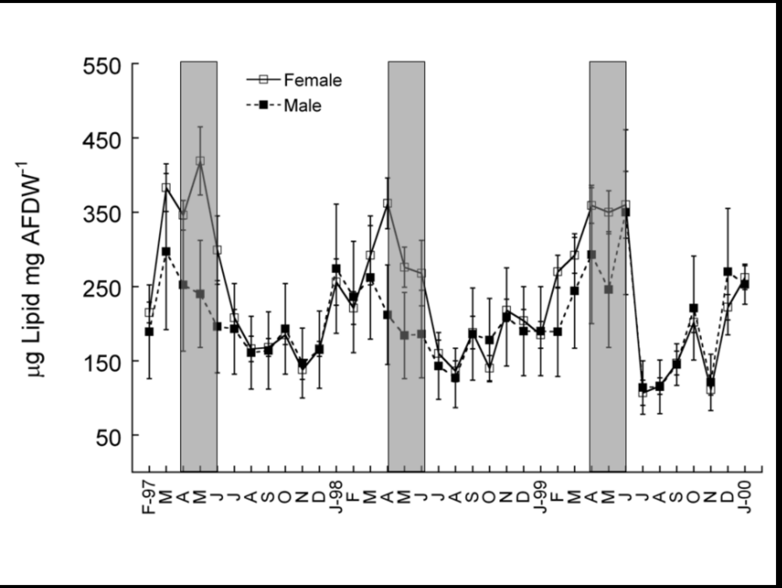
Animal-Dominated Communities

The physiological changes related with this resting state (dormancy) help the organisms to survive in adverse weather conditions and food scarcity.



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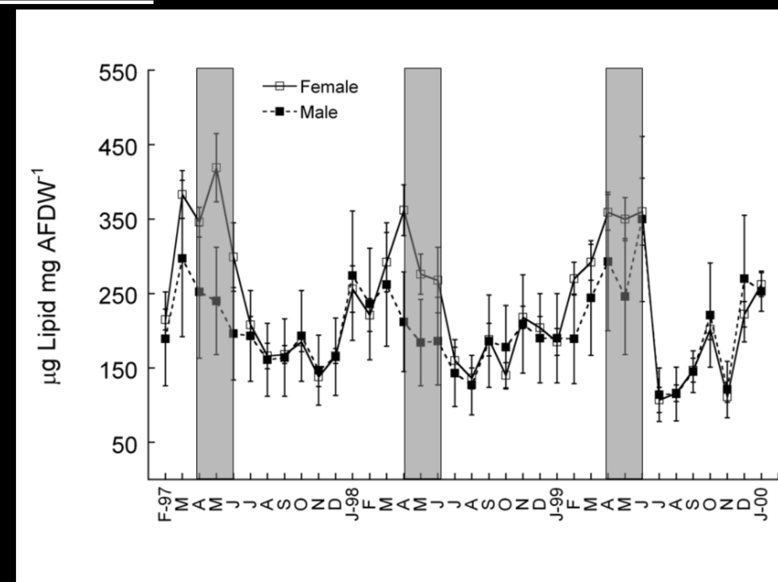
Animal-Dominated Communities

Biochemical composition in Mediterranean gorgonians shows periodic summer minimum energy storage of lipids and proteins, as well as a drop in late autumn (Rossi et al. 2006a; Rossi and Tsounis 2007).

These observations agree with the expected physiological changes associated to summer and late autumn energy shortage (Grémare et al. 1997; Rossi et al. 2003).



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Tendencies

The Mediterranean Sea is <u>one of the most important biodiversity hotspots</u> of the world with many different species and natural resources (Bianchi and Morri 2000; Coll et al. 2010).

The Mediterranean Sea is increasingly compromised by human activities, something that is <u>accentuated by its semi-enclosed configuration</u> which restricts its communication with the open ocean.

Mediterranean Sea has been identified as a hotspot of <u>sea warming effects</u>, <u>ocean acidification</u>, <u>alien species invasion</u> and other direct and indirect human perturbations, being considerably more impacted than other places of the world (Durrieu de Madron et al. 2011).

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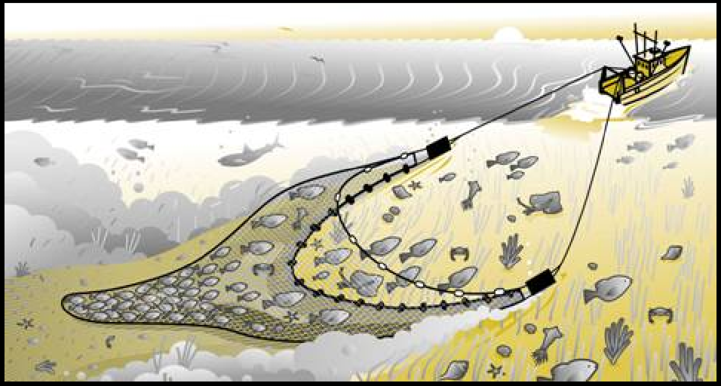
Tendencies
Directly Man-Induced Pressures
<u>Fishing Activity</u>

Although artisanal fleets and gears constitute the most important fisheries in the Mediterranean, nowadays there is a tendency in the development of semi-industrial fleets, mainly of <u>trawl fishing</u>.

<u>Bottom trawling ("pesca a strascico")</u> is towing the trawl along (<u>benthic</u> trawling) or close to (<u>demersal</u> trawling) the sea floors. Bottom trawling shows the <u>least degree of selectivity</u> with the widest-range impact on different organisms of the ecosystem due to <u>habitat destruction</u> and modification (Demestre et al. 2000), and displays the <u>largest impacts on some non-target groups</u> (i.e. organisms discarded).



This image shows <u>benthic bottom trawling ("pesca a strascico bentonica")</u>. We can see that it destroys the habitat by dragging the net on the sea bed. We also cannot target for a specific species as nets cannot choose what it catches

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Tendencies

Directly Man-Induced Pressures

<u>Fishing Activity</u>

At present, <u>bottom trawling</u> probably constitute the most acute direct problem for soft-bottom and detritic habitats, but was an evident source of destruction in other communities like <u>*Posidonia oceanica*</u> or <u>*Cymodocea nodosa*</u>. Together with species like the anglerfish (*Lophius piscatorius)* and other demersal fishes, the most common catches of bottom trawlers are <u>crustaceans</u>. The scientific assessments carried out on the red shrimp (*Aristeus antennatus*), the giant red shrimp (*Aristaeomorpha foliacea*) and the pink shrimp (*Parapenaeus longirostris*) are giving alarms for <u>overexploitation</u> (General Fisheries Commission of the Mediterranean 2012).

Gambero viola

Aristeus antennatus; Crustacea, Malacostraca, Decapoda, Aristeidae, *Aristeus*

Gambero rosso

Aristaeomorpha foliacea; Crustacea, Malacostraca, Decapoda, Aristeidae, *Aristaeomorpha*

Gambero rosa

Parapenaeus longirostris; Crustacea, Malacostraca, Decapoda, Penaeidae, *Parapenaeus*

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Tendencies

Directly Man-Induced Pressures

<u>Fishing Activity</u>

Common illegal practices in Mediterranean trawling include using nets with a <u>smaller mesh opening</u> than the permitted, <u>fishing in prohibited zones</u> and seabeds and using engines with a higher power than officially declared.

Though theoretically it would be simple to analyze the intensity of trawling in the Mediterranean using the track of the fleet with positioning systems, <u>the reality is that data does not exist or it is not available</u>.

Studies in the North Sea showed that the area trawled by these vessels each year is <u>equivalent to the size of the entire sea</u> (Leth and Kuijpers 1996), and this figure could be similar for the continental shelves in the Mediterranean.

The impact of trawling on the ecosystem can be categorized into two basic categories: (a) the <u>selectivity</u> of fishing techniques, with regard to the target species and to catching young fish and other sea animals that do not correspond to the target species, and (b) the <u>habitat destruction</u>, physical and biological consequences of the fishing arts on the bottom.

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Tendencies
Directly Man-Induced Pressures
Fishing Activity

The physical impact of benthic bottom trawling on ecosystems is very high, reducing the complexity of benthic communities (Auster 1998). All trawl components show a huge impact on soft-bottom environments yielding less species selectivity than other fishing techniques, damaging the substrate and its sessile species, and increasing its slow recuperation. The reduction of invertebrates (echinoderms, polychaetes and molluscs) in trawled zones reach up to 65 % when compared with areas where benthic bottom trawling has not taken place (Bergman and Hup 1992).

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Tendencies

Directly Man-Induced Pressures

Nutrient Increase

Mucilage: it is not clear which is the origin of the mucilage phenomenon, neither if it is related with local contamination (high nutrient concentration), but some authors suggest that in the Mediterranean Sea mucilage formation is a phenomenon that is directly related to nutrient increase.

It is certain that mucilage phenomenon has effects on the pelagic and benthic functioning (Pusceddu et al. 2009).

The mucilage phenomenon has been affecting different areas of the North-Western Mediterranean during the last decades (Mistri and Ceccherelli 1996a; Giuliani et al. 2005). The first record was in 1991 in the Tyrrhenian Sea (Innamorati et al. 1993), but it has been spreading in other areas during the last 20 years (Pusceddu et al. 2009).

Macroscopic phenomenon of extracellular polysaccharide gellation in the Northern Adriatic Sea: (a) remote sensing by satellite showing gel phase in red color; and (b) at 10 m depth captured by a scuba-diver (from: Urbani R., Sist P., Pletikapić G. et al. 2012, Diatom Polysaccharides: Extracellular Production, Isolation and Molecular Characterization. In: Karunaratne D. N. (ed) The Complex World of Polysaccharides, Intech, Rijeka

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Tendencies

Directly Man-Induced Pressures

Nutrient Increase

Mucilage phenomenon (http://video.nationalgeographic.com/video/news/marine-mucilage-vin), in which different algae produce a compact polysaccharide bloom that covers benthic communities (Giuliani et al. 2005), has a direct effect on suspension feeders, covering during a prolonged time their feeding structures. Entire populations can be affected (Mistri and Ceccherelli 1996a). However, the recovery of *Paramuricea clavata* colonies were also observed after 2 years of the event (Mistri and Ceccherelli 1996b).

Examples of alteration of Mediterranean Sea ecosystems: a) deposition of mucilage on coastal habitats (from: Bianchi C. N., Morri C., Chiantore M. et al., 2012, Mediterranean Sea biodiversity between the legacy from the past and a future of change. In: Stambler N. (ed) Life in the Mediterranean Sea: a look at habitat changes. Nova Science Publishers, New York, 1-55)

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Tendencies

Directly Man-Induced Pressures

Harvesting

Commercial sponges and red coral are the most affected animal species by direct impact on hard bottom substrates (Pronzato and Manconi 2008; Tsounis et al. 2010). *Spongia, Hyppospongia*, and *Corallium rubrum*, have been exploited for thousands of years. However, the most intense harvesting period is centred in the last two centuries.

Red coral has been harvested in a completely unsustainable manner (Tsounis et al. 2007), because no biological parameters are considered in the actual fishery models. The intense harvesting may collapse this resource at a local level in the first 50 m depth.

Other important harvesting activities that may cause severe direct or indirect impact on rocky benthic invertebrate assemblages and their habitat are the cases of the edible sea urchin *Paracentrotus lividus* (Sala et al. 1998a, b; Pais et al. 2007) and the rock-boring date mussel *Lithophaga lithophaga* (Fanelli et al. 1994; Guidetti et al. 2003).

Spongia; Demospongiae

Corallium rubrum; Anthozoa

Paracentrotus lividus ; Echinoidea

Lithophaga lithophaga; Bivalvia

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Tendencies

Directly Man-Induced Pressures

<u>Local Impacts</u>

Local impacts on suspension feeders due to the direct action of humans have also important consequences. Sala et al. (1996) found that the bryozoan *Pentapora fascialis* was more exposed to <u>SCUBA diver's action</u> in frequented than in non-frequented areas. The same perturbation (dead or partially injured colonies) or the lack of populations recovery were found in a long term monitoring of the gorgonian *Paramuricea clavata* and red coral *Corallium rubrum* (Coma et al. 2004; Linares et al. 2012).

Pentapora fascialis; Gymnolaemata

Paramuricea clavata; Anthozoa, Octocorallia, Alcyonacea, Plexauridae

Corallium rubrum; Anthozoa, Octocorallia, Alcyonacea, Coralliidae

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Tendencies

Directly Man-Induced Pressures

Local Impacts

Simple actions like bubbling near the colonies during the spawning period may cause the loss of sexual products before the fecundation process occurs, and therefore damaging the entire population (Tsounis et al. 2012).

SCUBA diving may be re-directed to a more respectful and appropriate diving behaviour

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Tendencies

Directly Man-Induced Pressures

<u>Local Impacts</u>

Other not so evident damages in suspension feeders assemblages are caused by <u>line fishing</u>, which <u>may affect more than 30 %</u> of the gorgonians in highly frequented areas by amateurs or professionals (Bavestrello et al. 1997; Bramanti et al. 2011). Lines denude the axis of the animals, which favours the development of <u>epibiont aggregates</u>. Mechanical stress has also been recorded, damaging colonies that can be partially or totally broken.

Other negative local impacts are those performed on seagrasses by the <u>anchoring of boats</u> from recreational boating that causes mechanical damage and habitat loss (Francour et al. 1999; Milazzo et al. 2004; Lloret et al. 2008).

Anchor damaging *Posidonia* beds https://www.youtube.com/watch?v=U23kg7vEe5E

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Tendencies
Indirectly Man-Induced Pressures
<u>Increasing Temperature</u>

The temperature increase observed in recent decades in the ocean has also been observed in the Mediterranean Sea.

In the Northwestern Mediterranean, two significant mass mortalities due to a <u>heat wave</u> (1999 and 2003) have been detected and their impact in hard bottom communities quantified (Cerrano et al. 2000; Perez et al. 2000; Garrabou et al. 2009). In these <u>mass mortality events</u>, the so-called <u>animal forest were affected in the first 10–50 m depth</u> in a wide range (more than 1,000 km of coast in the second heat wave), partially or totally killing gorgonians, corals, sponges or bryozoans. Not all the areas recovered in the same way after the heat wave. Unlike in the Port Cros National Park (Linares et al. 2005), *Paramuricea clavata* had high recruitment rates and tissue recover in the <u>Eastern Ligurian Sea</u> (Cupido et al. 2008, 2009), showing that population dynamics of gorgonians may differ with local environmental factors (Bramanti et al. 2009).

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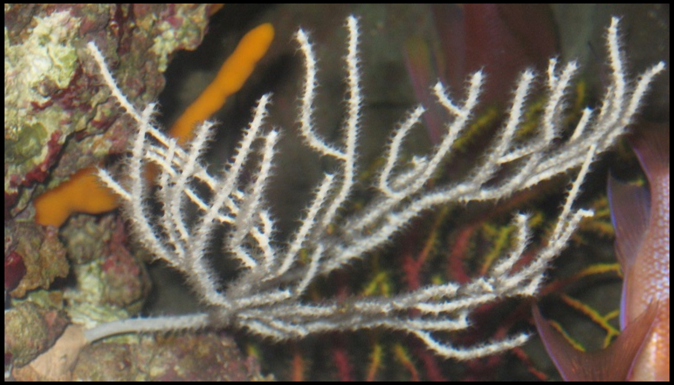
Tendencies

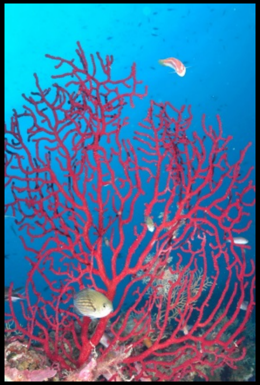
Indirectly Man-Induced Pressures

Increasing Temperature

Also the autoecology of the species is a key factor to understand the capacity to recover, being *Eunicella singularis* the species that showed the best recovery (Fava et al. 2010).



Eunicella singularis; Anthozoa, Octocorallia, Alcyonacea, Gorgoniidae



Paramuricea clavata; Anthozoa, Octocorallia, Alcyonacea, Plexauridae

Zoobenthos (II)

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Tendencies

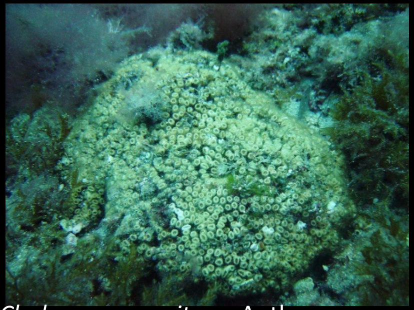
Indirectly Man-Induced Pressures

<u>Ocean acidification</u>

Another probable damage suffered by the benthic communities due to the climate change in the Mediterranean sea will be the ocean acidification effects.

<u>Calcareous organisms may be extremely affected by future ocean acidification</u>, as shown by Lombardi et al. (2011) in the bryozoan *Schizoporella errata*. But, the symbiotic anthozoan *Cladocora caespitosa* seems to be non-affected by pCO_2 increase. So, the common belief that calcification rates will be affected by ocean acidification in all calcifier organisms may not be the common rule (Rodolfo-Metalpa et al. 2010).

<u>Much work is needed to better understand the potential impact of pCO_2 increase</u>, not only in the physiology of organisms but also at the community and between organism interaction levels.



Cladocora caespitosa; Anthozoa, Hexacorallia , Scleractinia

Schizoporella errata; Gymnolaemata , Cheilostomata , Schizoporellidae

Zoobenthos (II)

[Gili J.-P., Sardà R., Madurell T. et al., 2014. Zoobenthos. In: Goffredo S., Dubinsky Z. (eds) The Mediterranean Sea: Its history and present challeges. Springer, Dordrecht, p 213-236]

Tendencies

Indirectly Man-Induced Pressures

Biological Invasions

Biological invasions in marine habitats represent one of the main factors of human-induced global changes (Occhipinti- Ambrogi and Savini 2003).

The Mediterranean Sea has been subjected to introductions of non-indigenous species by ship traffic and aquaculture, besides the Suez channel opening in Egypt (it was officially opened on November 17, 1869).

A total of 955 alien species are known in the Mediterranean, the vast majority of them have been introduced in the Eastern Mediterranean (718), less in the Western Mediterranean (328) and Central Mediterranean (267), and least in the Adriatic (171), being this numbers underestimated.

A total of 134 alien species are classified as invasive or potentially invasive (108 are present in the Eastern Mediterranean, 75 in the Central Mediterranean, 53 in the Adriatic and 64 in the Western Mediterranean). A large portion of these invasive species are benthic species.

Zoobenthos (II)

[Gili J.-P., Sardà R., Madurell T. et al., 2014. Zoobenthos. In: Goffredo S., Dubinsky Z. (eds) The Mediterranean Sea: Its history and present challeges. Springer, Dordrecht, p 213-236]

Tendencies
Indirectly Man-Induced Pressures
<u>Biological Invasions</u>

One of the most studied invasions by hard bottom suspension feeders is the case of *Oculina patagonica*. This species is a new <u>immigrant from the Southwest Atlantic</u> to the Mediterranean Sea, which has now a widespread distribution in the eastern Mediterranean (Fine et al. 2001). Coma et al. (2011) observed a longterm series of expansion in this symbiotic anthozoan, as well as the abundance of *Paracentrotus lividus*, a main grazer of macroalgae in hard bottom substrates. <u>Their results show that part of the increasing presence of *Oculina patagonica* may be explained by the increase of sea urchin abundance, which creates a barren rock suitable for the settling of the alien species (Coma et al. 2011)</u>.

Oculina patagonica; Anthozoa, Hexacorallia, Scleractinia, Oculinidae

Paracentrotus lividus; Echinoidea, Camarodonta, Parechinidae

Zoobenthos (II)

[Gili J.-P., Sardà R., Madurell T. et al., 2014. Zoobenthos. In: Goffredo S., Dubinsky Z. (eds) The Mediterranean Sea: Its history and present challeges. Springer, Dordrecht, p 213-236]

Tendencies
Man-Induced Pressures
Summary

Mediterranean benthic communities have been perturbed and changed by human activities since the beginning of the civilization.

With the progressive increase in human population in the coastal zone, the impact has increased especially on the coast but also along the continental shelf.

Trawling and pollution drastically affect the loss of diversity and benthic habitat reduction.

The anthropogenic effects must be added to those produced by global warming that affect especially the shallow populations and may favor the proliferation of alien/invasive species.

The conservation of the Mediterranean requires urgent measures such as marine protected areas and a proper change in its management, based on rigorous scientific knowledge (Rield 1980; Sala 2004).